**1**

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|---|---|---|---|---|
| (a) | (i) | **A** hydrogen ;<br>**B** glycosidic ; | 2 | **DO NOT CREDIT** 'H bond' as this is not a name<br>Correct spelling only.<br>**IGNORE** α or β or numbers |
| (a) | (ii) | hydrolysis / addition of water ; | 1 | |
| (a) | (iii) | β / beta , glucose ; | 1 | Must be qualified as β or beta or B or b |
| (b) | | enzymes are specific ;<br>the , carbohydrate molecules / substrates , are different shapes ;<br>active site and substrate are complementary ;<br>so that substrate will fit / formation of ESC ;<br>lock and key / induced fit ; | 3 max | |
| (c) | (i) | pH much , higher / less acidic , than optimum (for enzyme 2) ;<br>change in charge of active site ;<br>hydrogen / ionic , bonds break ;<br>tertiary structure / 3D shape / active site shape , altered ;<br>enzyme / tertiary structure , denatured ;<br>substrate no longer fits active site / ESC does not form ; | 3 max | Needs idea of much greater or too high<br>**DO NOT CREDIT** just 'higher than' or 'above'<br>**DO NOT CREDIT** too / more , alkaline<br>**DO NOT CREDIT** peptide / disulphide , bonds break<br>**DO NOT CREDIT** in context of heat / vibration<br>**IGNORE** ref to denaturing active site<br>**IGNORE** ref to denaturing active site<br>**DO NOT CREDIT** kill / die<br>'substrate doesn't bind to enzyme' is not quite enough |
| (c) | (ii) | *Mark 1st response on each numbered line unless no answer on one line, then mark 1st 2 answers*<br>temperature ;<br>substrate concentration ;<br>enzyme concentration ; | 2 max | **IGNORE** ref to time |
| (d) | | ***Marking points 2 – 6 can be applied to the standard solutions or the sample*** | | |
| | 1 | using , standard / known , concentrations (of reducing sugar) ; | | e.g. serial dilutions |
| | 2 | heat with , Benedicts (solution) / $CuSO_4$ + NaOH ; | | **ALLOW** boil / > 80°C **DO NOT CREDIT** warm |
| | 3 | (use of) same volumes of solutions (each time) ; | | **DO NOT CREDIT** amount / quantity |
| | 4 | (use of) excess Benedicts ; | | |
| | 5 | changes to , green / yellow / orange / brown / (brick) red ; | | |
| | 6 | remove precipitate / obtain filtrate ; | | **CREDIT** description of method<br>e.g. filtering / centrifuging & decanting |
| | 7 | calibrate / zero , colorimeter ; | | |
| | 8 | using , a blank / water / unreacted Benedicts ; | | |
| | 9 | use (red) filter ; | | |
| | 10 | reading of , transmission / absorbance ; | | **ACCEPT** 'measure how much light , does / does not , pass through' |
| | 11 | more transmission / less absorbance , of filtrate = more sugar present ; ora | | If precipitate is **clearly indicated** as being present in sample, **ALLOW** 'less transmission / more absorbance , = more sugar present' |
| | 12 | (obtain) calibration curve ; | | |
| | 13 | plotting , transmission / absorbance , against (reducing) sugar concentration ; | | |
| | 14 | use reading of unknown sugar solution and read off graph to find conc. ; | 6 max | |
| | | **Total** | **18** | |

**2**

| | | | | |
|---|---|---|---|---|
| (a) | (i) | blue-black / black / dark blue ; | 1 | **ACCEPT** dark purple / purplish-blue<br>**DO NOT CREDIT** blue or purple unqualified by darkness<br>**ACCEPT** acceptable colour change |
| (a) | (ii) | | | **CREDIT** marking points from clearly labelled diagram max 1 if incorrect charges are on atoms |
| | 1 | between oxygen and hydrogen (atoms) ; | | **1 DO NOT CREDIT** molecules / ions |
| | 2 | (between) electronegative / $\delta^-$, and electropositive / $\delta^+$ ; | 2 | **2 DO NOT CREDIT** ions / + and –<br>**2 ACCEPT** slight / partial (negative / positive), charge |
| (a) | (iii) | | | **IGNORE** refs to denaturation |
| | 1 | hydrogen / H, bonds break ; | | |
| | 2 | helix, lost / unravels / AW ; | | **2 ACCEPT** spiral / coil |
| | 3 | iodine, released / no longer in complex / AW ; | 2 max | **3 ACCEPT** no longer contained in helix |
| (b) | 1 | take samples at a range of times / AW ; | | |
| | B2 | same volumes (of solutions) added / removed (each time) ; | | **B2** must be in context of Benedict's test rather than reaction mixture |
| | B3 | heat with, Benedict's (solution) / $CuSO_4$ and NaOH ; | | **B3 DO NOT CREDIT** boil / warm<br>**B3 DO NOT CREDIT** if Benedict's added to the mixture at the beginning |
| | B4 | (use of ) excess Benedict's ; | | |
| | B5 | changes to, green / yellow / orange / brown / (brick) red ; | | |
| | C6 | remove precipitate / obtain filtrate ; | | **C6 CREDIT** description of method<br>e.g. filtering / centrifuging / decanting |
| | C7 | colorimeter ; | | |
| | 8 | calibrate / zero, using, a blank / water / (unreacted) Benedict's ; | | **8 IGNORE** 'control' |
| | 9 | use (red / orange) filter ; | | **9 DO NOT CREDIT** if colour of filter is incorrect |
| | T10 | reading of, transmission / absorbance<br>OR<br>mass of precipitate ; | | **T10 ACCEPT** 'measure how much light, does / does not, pass through' |
| | 11 | more transmission / less absorbance, of filtrate,<br>OR<br>greater mass ppt, = more maltose present ; **ora** | | **11** if unfiltered Benedict's / precipitate is **clearly indicated** as being present **in sample**, **ACCEPT** 'less transmission / more absorbance, = more maltose present'<br>**11 DO NOT CREDIT** if precipitate is added to colorimeter |
| | 12 | using, standard / known, concentrations (of maltose) ; | | **12 CREDIT** 'serial dilutions' |
| | 13 | (obtain) calibration curve ; | | |
| | 14 | plot, transmission / absorbance / mass of ppt, against (reducing sugar) concentration ; | | |
| | 15 | use graph to read off concentration of maltose / AW ; | 6 max | |
| | | QWC – correct sequence ; | 1 | 1 of mps **B2** to **B5**, *then* mp **C6** or **C7**, *then* mp **T10** |

| | | | | |
|---|---|---|---|---|
| (c) | (i) 1 | increases / greater / faster ; | | 1 ACCEPT any time between 3.45 and 3.55 min. |
| | 2 | reaction completed in / plateaus after / concentration is 100% after, 3.5 minutes ; | | |
| | 3 | figures with units to support mp 1 ; | 2 max | 3 two maltose concentrations (+ or – chloride) for a given time or two times (+ or – chloride) for given maltose concentration.<br>3 ACCEPT calculated difference<br>3 DO NOT CREDIT if '%' and 'min.' not given<br>3 ACCEPT any concentration within ± 1 % and time within ± 0.05 min. |

| Presence or absence of chloride ions | The percentage concentration of maltose (%) present every half a minute | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.0 min | 0.5 min | 1.0 min | 1.5 min | 2.0 min | 2.5 min | 3.0 min | 3.5 min | 4.0 min |
| Chloride ions present | 0 | 24 | 54 | 70 | 80 | 88 | 95 | 100 | 100 |
| Chloride ions absent | 0 | 12 | 20 | 29 | 36 | 40 | 45 | 48 | 50 |
| Difference in maltose concentration When chloride ions are either present or absent | 0 | 12 | 34 | 41 | 44 | 48 | 50 | 52 | 50 |

Allow a + /- 1% for any concentration of maltose and a +/- 2% for the difference in maltose concentrations

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|---|---|---|---|---|
| (c) | (ii) 1 | (acts as a) cofactor ; | | 1 IGNORE 'coenzyme' |
| | 2 | ($Cl^-$) binds to, enzyme / amylase / amylose / substrate ; | | 2 ACCEPT binds to, active site |
| | 3 | enzyme substrate complex / ESC, forms more, easily / quickly ; | 2 max | 3 ACCEPT description |

| | | | | |
|---|---|---|---|---|
| (c) | (iii) | | | **Mark the first three answers only regardless of which line they are on**<br>DO NOT CREDIT refs to, time |
| | 1 | temperature ; | | |
| | 2 | pH ; | | |
| | 3 | enzyme / amylase / chloride, concentration ; | | 3 IGNORE 'amount' or 'volume'<br>3 DO NOT CREDIT 'concentration' unqualified |
| | 4 | substrate / starch / amylose, concentration ; | | 4 IGNORE 'amount' or 'volume'<br>4 DO NOT CREDIT 'concentration' unqualified |
| | 5 | constant / regular, stirring ; | | |
| | 6 | (fixed) volume of solution (removed each time for sampling) ; | 3 max | |
| | | **Total** | **19** | |

**3**

| | | | | |
|---|---|---|---|---|
| (a) | (i) | X ; | 1 | |
| | | | | |
| (a) | (ii) | 1 substrate / PABA, **and**, inhibitor / sulfonamide, similar shape;<br>2 able to, bind / fit into / block, active site ;<br>3 (shape) complimentary to active site ;<br>4 both have, hex / benzene / 6-C, (ring) ;<br>5 both have, $NH_2$ / amine ;<br>6 correct ref to a difference between sulfonamide and PABA ; | 3 max | 1 **ACCEPT** similar structure **DO NOT CREDIT** same shape<br>3 **DO NOT CREDIT** refs to PABA and sulfonamide being complementary to each other or to the enzyme (alone)<br>6 e.g. only sulfonamide contains S<br>sulfonamide has 1 more $NH_2$ group<br>sulfonamide has $SONH_2$ but PABA has $N_2$<br>only PABA has COOH group |
| | | | | |
| (b) | (i) | *without inhibitor*<br>1 more, PABA / substrate, molecules enter active site ;<br>2 more, enzyme substrate complexes / ESCs, formed ;<br>3 at low concentration not all active sites occupied /<br>at high concentration all active sites occupied ;<br>4 achieves / reaches, max (turnover) rate / $V_{max}$ ;<br>5 (at high substrate concentration) enzyme concentration limiting ; | 3 max | 1 **ACCEPT** more successful collisions between substrate and active site<br>3 **ACCEPT** active sites filled / no free active sites<br>**DO NOT CREDIT** active sites run out<br>4 **ACCEPT** 'cannot work any quicker'<br>**DO NOT CREDIT** 'optimum rate' or 'rate levels off' |
| (b) | (ii) | *with inhibitor*<br>1 inhibitor / sulfonamide, can,<br>fit / block / bind to / compete for, active site ;<br>2 (occupies it) for a short time / temporary / reversibly ;<br>3 fewer active sites available (for substrate) / AW ;<br>4 (idea of) more substrate reduces chance of inhibitor getting in; | 2 max | 3 **ACCEPT** substrate can't access active site<br>4 **ACCEPT** more ESC formed in context of overcoming inhibition / substrate can out-compete inhibitor |
| (c) | | 1 mutation ;<br>2 sulfonamide is selective, agent / pressure ;<br>3 resistant survive / non resistant die ;<br>4 (resistance) allele / gene / mutation,<br>passed to, offspring / next generation ;<br>5 (happens) over many generations ;<br>6 AVP ; | 4 max | **DO NOT CREDIT** immune for **any** mark point<br>3 **IGNORE** refs to (survivors) breed / reproduce ;<br>5 **IGNORE** refs to time. Look for generations<br>6 e.g. mutation is, **random** / spontaneous<br>allele / gene, passed on by,<br>plasmids / horizontal transmission |

**4**

| | | | | |
|---|---|---|---|---|
| (a) | | (enzymes are) proteins / used in metabolism / used in named metabolic pathway ;<br><br>alter rate of (chemical) reaction / lowers activation energy / provides alternative route for reaction / is not changed / is not used up ; | 2 | **ACCEPT** 'used in reactions , in organisms / in the body'<br>**IGNORE** 'biological / enzyme / in nature'<br><br>**ACCEPT** does not take part in reaction<br><br>**Note** 'speed up metabolic reactions' **= 2 marks** |
| (b) | (i) | time ; | 1 | **Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**<br><br>**IGNORE** 'how long'<br>**IGNORE** correct units |
| (b) | (ii) | **P1** *idea of* different samples have different concentrations of, catalase / enzyme ;<br><br>***One of***<br>**M1** source the extract for the whole experiment from a single source ;<br>**M2** thorough , mixing , required before use ;<br>**M3** filter / purify , extract ;<br>**M4** *idea of* using , known / standard , concentration of enzyme ;<br>**M5** commercial source of catalase ; | 2 | The M mark can be awarded without a correct P mark<br><br>**P1** Look for the idea of variation within the sample (e.g. different amounts)<br>**CREDIT** examples of lack of uniformity such as: breakage of cells / surface area / mixing / disruption of lysosomes / changes to enzyme shape (caused by blending process) / presence of other substances interfering with reaction<br><br>**IGNORE** refs to celery being a poor source of catalase<br><br>**M1 ACCEPT** 'from same plant' |
| (b) | (iii) | repeat / replicate ;<br>compare replicate values / identify anomalous results ;<br><br>mean / range / standard deviation / error bars / % error ;<br><br>compare results with , others / book / internet , values / results ; | 2 max | e.g compare replicates with Table 2.1<br><br>**IGNORE** average<br><br>Must contain the idea of other investigators<br>**ACCEPT** 'look up normal values on the internet' |
| (c) | (i) | **1** rate , rises / increases , initially ;<br>**2** peak at / maximum at / highest at / decrease after, 40(°C) ;<br><br>**3** (overall) fall more rapid than rise ;<br><br>**4** *idea that* before peak / after peak , temperature increase has increasing effect on rate ;<br>**5** comparative figures to support any point ;<br><br>**6** no , reaction / oxygen produced , at 60(°C) ; | 4 max | **IGNORE** explanations<br>**1 DO NOT CREDIT** if 'rate' not stated for this mp only<br>**2 ACCEPT** optimum<br><br>**3** Look for a comparative statement<br><br>**4 ACCEPT**, e.g., line is steeper between 30 and 40 than between 10 and 20.<br>**5** Two temperatures and two rates, **with units**. Or calculated difference with appropriate units, e.g. rate doubles between 10 and 20°C **or** $Q_{10} = 2$<br>**6 ACCEPT** rate is 0 at 60 |
| (c) | (ii) | 2 ; | 1 | **IGNORE** units |
| (c) | (iii) | temperature ;<br>maximum / peak / $V_{max}$ ;<br>denatured ;<br>active ; | 4 | **Mark the first answer for each letter.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**<br><br>**ACCEPT** kinetic energy / KE<br>**ACCEPT** optimum / optimum temperature<br>**IGNORE** descriptions |
| | | **Total** | [16] | |